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## PSYCHO-PHYSICAL TESTS OF AVIATORS

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THE application of psychology to the problem of discovering special aptitude for flying is one of the interesting developments of the war. All such work in this country has had the benefit of that done by the French. Nepper, the most distinguished of them in this field, is primarily a physiologist, but he is aware that the attention to the physical fitness of the man to be trained as a pilot leaves out of account many important things. His idea has been that a thorough clinical examination gives assurance of excellent sense organs, but it leaves quite undecided whether the future aviator will be able to make proper use of the impressions which these sense organs bring to him. He might have added that such an examination gives assurance that the future aviator will have normal muscles, but gives no assurance that he will be able to make use of these muscles with unusual skill.

Nepper laid stress upon two qualifications which he regarded as central and essential for aviation; namely, coolness and the power to make rapid decisions. The power to make rapid decisions he felt could be tested by means of the standard laboratory experiments in "personal equation," or what is more commonly known among us as reaction time; that is, the time which it takes a person to respond by a movement—perhaps of the finger—to some signal. Such signals Nepper gave in the regions of sight, of hearing and of touch, measuring the time of the person's response by electric keys connected with a delicate chronoscope. Having taken a number of such measurements in each of these three senses, he counted it against the man if his reaction time either was too slow or was too irregular. And the person was too slow for him if the average time of his reaction for sight was more than .01 of a second slower than the average time which he found among those he examined, such average time being for sight, .193 sec., for hearing .144 sec., and for touch .142 sec. He also set a narrow limit of irregularity which he permitted in the man's reactions, and if the person was more irregular than this, he regarded it as an indication that the man was unsuitable for training as a flyer.

Coolness Nepper tested by delicate apparatus familiar to all psychologists and physiologists, which gives a written record of one's breathing, of the changes of volume of blood in his finger, and of the steadiness with which it is possible for him to hold his hand, these records being obtained from the aviator in the first place under comparatively normal conditions, which were in due time suddenly changed by giving some violent form of surprise, either by a flash of light, or by cold water, or by a blank shot from a pistol near the man. On the basis of these two forms of experiment he classified his candidates into good and poor, and rejected those whom he regarded as unsuited for the work of aviation.

The Italians also during the great war have used psycho-physical methods in the selection of aviators, the two men whose names have come most prominently in this work to us being Gemelli and Gradenigo. They too made use of the reaction-time experiment and of the test of emotional steadiness, much after the French fashion, and yet with modifications. An interesting enlargement of procedure on their part was by means of what is known as a "Carlinga," which reproduced in some respects the cockpit of an airplane and could be moved in various directions. The candidate blindfolded was required to indicate the vertical after he had been tilted from the vertical; and again, without being blindfolded, was required to respond quickly by means of his "joy stick" to some sudden tilt of the machine. His value as a future aviator was estimated in part by the character of his responses under these conditions.

The work in America, as was said, has had the benefit of this work on foreign soil. With us, the research, beginning among civilian scientists, was in due season taken over by the Air Service of the Army and more particularly in the later months of the war by the Medical Research Laboratory of the Air Service at Mineola. In order to understand more fully the conditions under which the work was planned, it may be of interest to tell briefly the character of the examination of aviators before any psycho-physical features were introduced.

The candidate appeared before some one of the many Aviation Examining Boards established throughout the country, and his examination by the board took two interestingly different directions. The candidate was given in the first place a most careful physical and medical examination by medical officers in the army and he was also given what was designated as a professional and mental examination by one or more officers who were not in the Medical Corps. This latter examination

was based upon the candidate's carefully written answers to several pages of questions that were put to him with regard to his family history, his education, his business experience, his athletic interest and training, the character of the responsibilities placed upon him in civil life, the organizations to which he belonged, and his military experience. He had also to furnish letters testimonial from persons who knew him well, and credentials of his schooling. Of particular importance was the personal interview, when the applicant faced his military examiners and was required to clarify or supplement the facts given in the ways just described. Thus by a direct personal judgment assisted by various means, it was decided whether the man should go into training or should be courteously and with due appreciation told "No."

The method is on the whole an excellent one, though any one who has had experience as an officer upon such a board knows how fallible a judgment often issues from the professional and mental side of the board's examination. It is unquestionably true that many an applicant gives far better promise than his later performances fulfill, and, on the other hand, men are thrown out by such a method who would have made successful aviators.

The purpose of proposing psycho-physical tests in the Air Service was not to do away with any part of the several examinations here described, but rather to supplement these examinations and reduce the probability of error in them. And in particular the research with which this paper is concerned aimed to discover whether certain and particular tests that might be proposed would actually assist appreciably the examinations already established in the Aviation Examining Boards. The method was not to adopt tests out of hand on the assumption that they must of necessity distinguish promising from unpromising candidates. Rather the investigation aimed to put the tests to trial and to find out whether they actually gave evidence of worth. Until they could give scientific evidence of their value, that value was regarded as wholly problematic.

The tests which were subjected to investigation were in part similar to those used by Nepper and Gradenigo; but, for the sake of wider exploration, many other tests were brought to trial. Every investigator is in debt to many others, and especially is this true in the present case. Professor Brown and his assistants at the University of California, Professor Thorndike, of Columbia University, Professor Henmon, of the

University of Wisconsin, and Doctor Burtt, of Harvard University, made possible by their scientific judgment the research here reported. Nor within the Army itself was the work possible save by a hearty personal cooperation of a great number of officers and men, in Washington, in Mineola, and at San Diego. Everywhere in the army such work as this found something that could not be had by force of mere authority and orders.

Besides reaction time and emotional stability, aviators were tested as to their power rapidly to learn to form several complicated and untried combinations of muscular movements not unlike those which an aviator has to learn, the idea being that in this way the least skillful persons might be eliminated. Other tests were concerned with a careful recording and measuring of the success with which a person could stand motionless with eyes open and with eyes closed, indicating general and constant control over the muscles of his body as a whole. He also had to show evidence of the fineness with which he could perceive gradual departures of his entire body from the perpendicular brought about by a mechanism of screws and levers, the test being aimed at his sensitivity, his power to perceive, rather than to control, since it might well be asked whether a nicety of perception of the position of the body is an important factor in guiding the aviator as he restores his airplane to its proper balance in the air. And, since the landing of the airplane is one of the difficult parts of the aviator's early task and requires judgment as well as careful response and control as he approaches the ground swiftly with his ship, he was tested as to his power to continue in imagination certain fragmentary curves that were given him; for his skill in landing might well require him to anticipate where his present course at any moment would, if continued, carry him and how he must needs alter it to make it suitable in angle, speed and place. A simple test of dexterity was also used; the candidate was required to balance one of a graded series of rods vertically upon his finger for a stated time to see how short a rod he could balance; and his success or failure in this was accurately measured.

Even after findings from such tests had been obtained, they still were regarded as subject to check and suspicion. The tests were repeated with different groups of aviators at the same field, and under the direction of different officer-scientists at different fields, in order to reduce the danger that the particular findings might be the result of chance or of some special

interest or error or suggestion of those in charge of the experiments. And as an essential element in determining the value of any test, it was necessary to have the best judgment of the army officers who were actually in charge of the aviators' training in flying. For the psychologist did not assume that he could as yet estimate by his tests the fitness of any person for flying. He simply wished to discover whether, as a matter of fact, there was any parallel between the degree of success with which a person could pass a given psycho-physical test and that person's peculiar skill as an aviator; and this skill must be judged not by a psychologist, but by one practically versed in flying, himself a flyer and a trainer of flyers. A possible parallel between success in aviation and success in passing the psycho-physical tests would constitute what is known technically as a "correlation," to be indicated by a mathematical expression known as the "coefficient of correlation."

The outcome of the experiments was that, as a matter of fact, these tests all showed a relatively low correlation with flying ability, and yet, in some of the tests, there actually was invariably a correlation of respectable amount. And this made it clear that the test itself might, with proper precautions and supplementing, be used with some degree of reliability to assist in the work of selection.

The tests which under this stern trial proved to be of value were those on the perception of gradual tilt, on the power to stand steadily, as judged by the record which a man makes when a writing point attached to his head moves over a smoked surface, on his power quickly to discriminate between a sudden jerk of his body to the right or to the left, particularly when this is combined with his reaction time to a visual signal and to an auditory signal, and on the steadiness of his hand when a pistol shot is fired behind his back. The tests which did not scientifically justify themselves were those upon a person's power to learn certain complicated combinations of movement of hand and foot, on the power to continue in imagination a fragment of a curve presented to him in model, and on dexterity. This latter test was disapproved not so much because it arrived at nothing which could be connected statistically with flying ability, as that it could so largely be influenced by practise, and practise would be invited if the test were introduced as a regular part of a board's examination, when the candidates would soon know beforehand that they would be tested on this feat of dexterity.

The research may therefore be regarded as having had its measure of success. Tests were actually found by which it was possible to give a more assured judgment than was possible by credentials or by personal interview that the candidate could learn to use with skill the sound and normal body which the medical examination gave assurance that he possessed. But it will perhaps not be needless to repeat that in the writer's judgment such tests are not, nor do they promise to become, a substitute, but only an assistance to the other and standard means of estimating a candidate's ability.

The experiments bring home to one the exceeding complexity of the flyer's ability. His power to attain success in his hazardous and delicate work evidently is not due to any one factor in his psycho-physical constitution, nor to any small group of factors, but rather to a happy constellation of many factors, of which each counts only in a limited way.

A French aviator who examined with some care and moderate approval the apparatus which has been described, expressed appreciation of the work, but expressed also his conviction that such tests did not touch the central fitness of the aviator, the "heart" of the man, meaning, no doubt, the courage, the temperament, the spirit which he would show only in the midst of danger or of crushing fatigue. Such a reservation in judgment the writer feels is not to be despised even by those enthusiastic over instrumental means of discovering special ability. Such doubts, however, should not discredit the laboratory means, but rather should keep them in their place. In so difficult a matter as that of determining special ability to fly, all agencies and aids are needed. Any one means is fallible; but when all good means are joined, there is prospect of far greater success, of far less error and failure. Especially would it be unwise to say that we have already exhausted the possibilities which lie in psycho-physical tests. Judging by the past, it seems likely that a research of this kind has merely come to the threshold of its opportunity and that it will with time and intelligence and ardor enter a region of fruitful work of which we have now but a faint idea.